Biogenic VOC Emissions in CESM

(aka MEGAN 2.1)

Colette L. Heald

BIOGENIC VOC EMISSIONS: MEGAN v2.1

$$F = \gamma \rho \sum_i \varepsilon_i \chi_i$$

ε_i : emission factor at standard conditions for vegetation type *i*
χ_i : fractional areal coverage
γ : emission activity factor
ρ : canopy loss and production factor (=1)

Isoprene only
[Heald et al., 2008]

γ=f(     , [CO_2])

Account separately for light-dependent and light-independent fraction for radiation and temperature activity factors:

$$\gamma_{P,i} = (1 - LDF_i) + LDF_i \gamma_{P\_LDF}$$

$$\gamma_{T,i} = (1 - LDF_i)\gamma_{T\_LIF,i} + LDF_i \gamma_{T\_LDF,i}$$

[Guenther, Heald et al., in prep]

Expand from previous treatment of isoprene + lumped monoterpenes and lumped OVOC → now simulate 19 compound classes and 150 possible individual species!

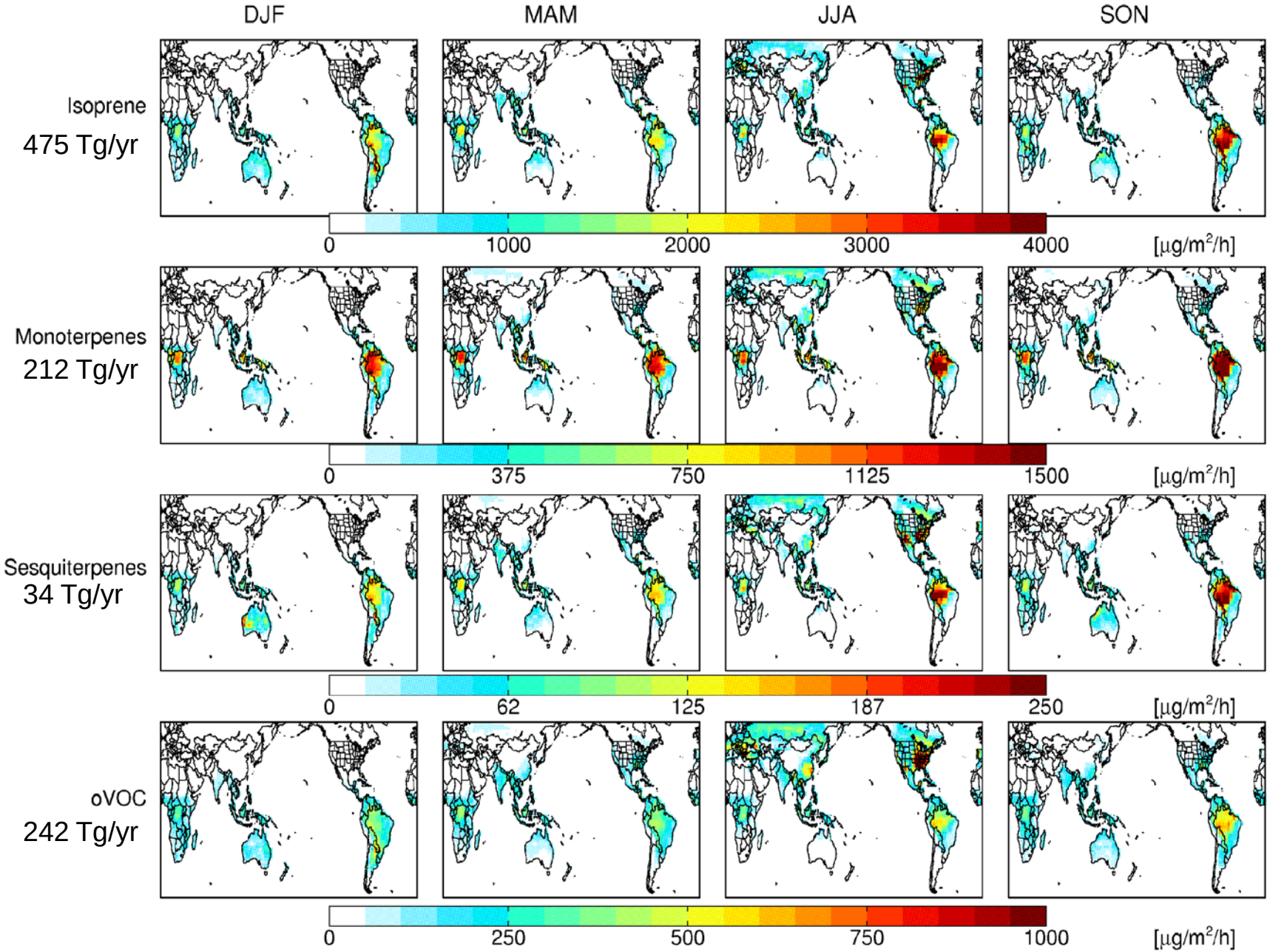
MEGAN 2.1 IN CLM

Emission factors now mapped to 16 CLM PFTs.
Allows for improved calculation of emissions with changing land cover…

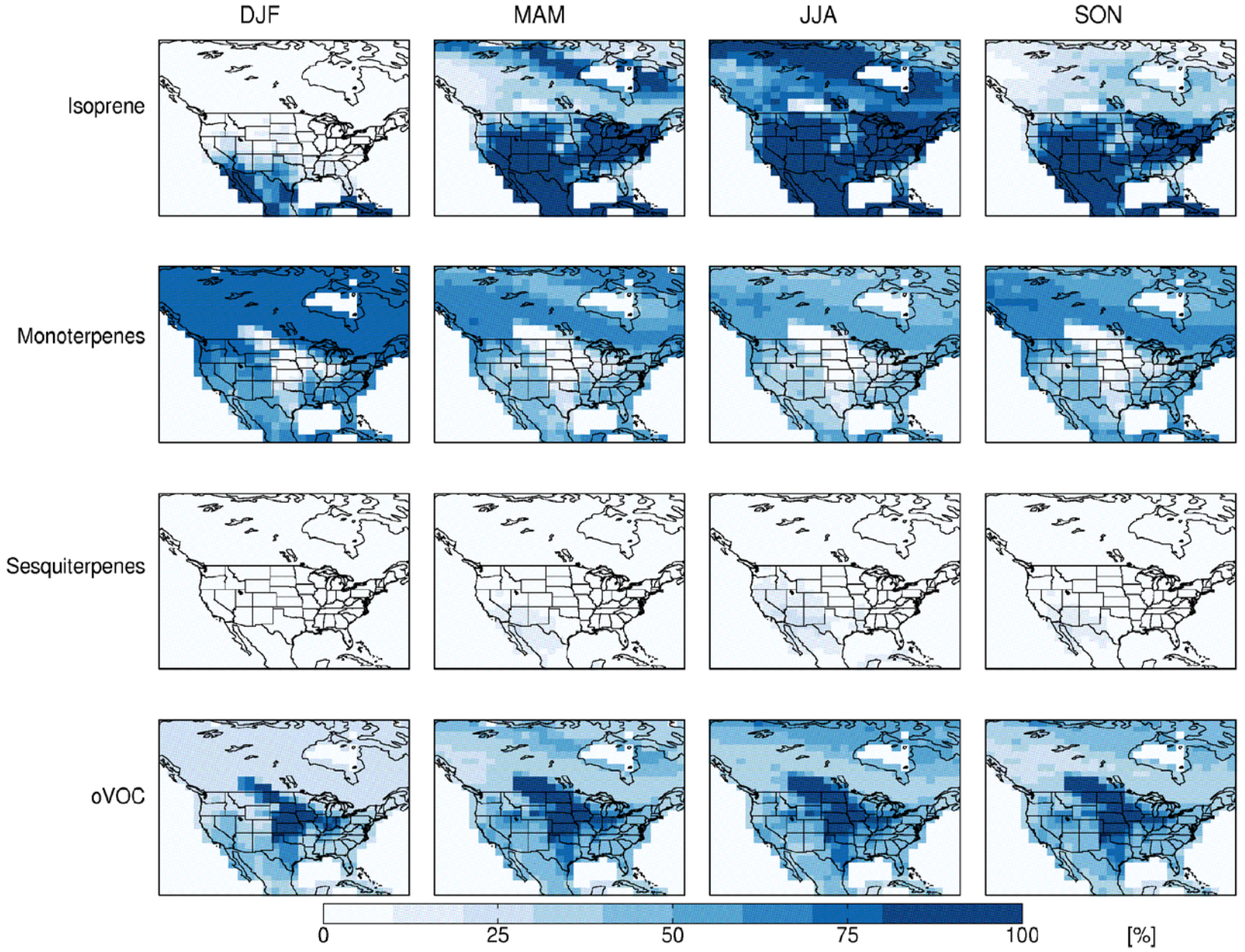
Compound Class	EF_1	EF_2	EF_3	EF_4	EF_5	EF_6	EF_7	EF_8	EF_9	EF_{10}	EF_{11}	EF_{12}	EF_{13}	EF_{14}	EF_{15}	EF_{16}
Isoprene	600	3000	1	7000	10000	7000	10000	11000	2000	4000	4000	1600	800	200	1	50
Myrcene	70	70	60	100	30	100	30	30	30	50	30	0.3	0.3	0.3	0.3	0.3
Sabinene	70	70	40	100	50	100	50	50	50	70	50	0.7	0.7	0.7	0.7	0.7
Limonene	100	100	130	100	80	100	80	80	60	100	60	0.7	0.7	0.7	0.7	0.7
3-Carene	160	160	80	50	30	50	30	30	30	100	30	0.3	0.3	0.3	0.3	0.3
Ocimene	70	70	60	200	120	200	120	120	90	150	90	2	2	2	2	2
β-Pinene	300	300	200	150	130	150	130	130	100	150	100	1.5	1.5	1.5	1.5	1.5
α-Pinene	500	500	510	800	400	800	400	400	200	300	200	2	2	2	2	2
Other Monoterpenes	180	180	170	200	150	200	150	150	110	200	110	5	5	5	5	5
Farnascene	40	40	40	60	40	60	40	40	40	40	40	3	3	3	4	4
β-Caryophyllene	80	80	80	60	40	60	40	40	50	50	50	1	1	1	4	2
Other Sesquiterpenes	200	200	200	200	150	200	150	150	150	150	150	2	2	2	2	2
MBO	200	10	0.01	0.01	0.01	0.01	0.01	2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Methanol	800	800	800	400	800	400	800	800	800	800	800	400	400	400	800	800
Acetone	240	240	240	240	240	240	240	240	240	240	240	80	80	80	80	80
CO	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
Bidirectional VOC	500	500	500	500	500	500	500	500	500	500	500	80	80	80	80	80
Stress VOC	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Other VOC	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140

- *Emission factors as well as sub-speciation of classes and constants in MEGAN2.1 algorithm now included in input file (not hard-wired), so can be easily updated*
- *Gridded map of emission factors available for isoprene (includes differences in plant species)*

BVOC EMISSIONS: MEGAN v2.1 in CLM (2000, CAM4)



FRACTIONAL CONTRIBUTIONS TO BVOC EMISSIONS OVER NORTH AMERICA



BVOC GLOBAL EMISSIONS IN MEGAN v2.1

Compound Class	Global Emissions ($Tgyr^{-1}$)	
Isoprene	475	
Myrcene	12.2	Monoterpenes
Sabinene	12.6	
Limonene	13.9	
3-Carene	9.1	
Ocimene	15.1	
β-Pinene	23.8	
α-Pinene	97.8	
Other Monoterpenes	27.5	
Farnascene	6.1	Sesquiterpenes
β-Caryophyllene	6.7	
Other Sesquiterpenes	21.1	
MBO	1.1	OVOC
Methanol	78.2	
Acetone	39.9	
CO	73.0	
Bidirectional VOC	48.5	
Stress VOC	44.0	
Other VOC	29.9	

CAM-chem Results

Louisa Emmons, Xiaoyan Jiang

- Free-running vs GEOS-5
- Active CN in CLM vs not
- Mapped vs PFT-based isoprene EFs

Species (CAM-chem)	Free-running CLM-CN off	Free-running CLM-CN on	GEOS-5 CLM-CN on
ISOP	465	452	383
C10H16	107	129	119
CH3OH	78	93	85
CH3COCH3	40	50	47
CH3CHO	19	19	17
C2H5OH	19	19	17
CH2O	4.4	4.7	4.3
CH3COOH	3.3	3.5	3.2

Tg(species)/yr

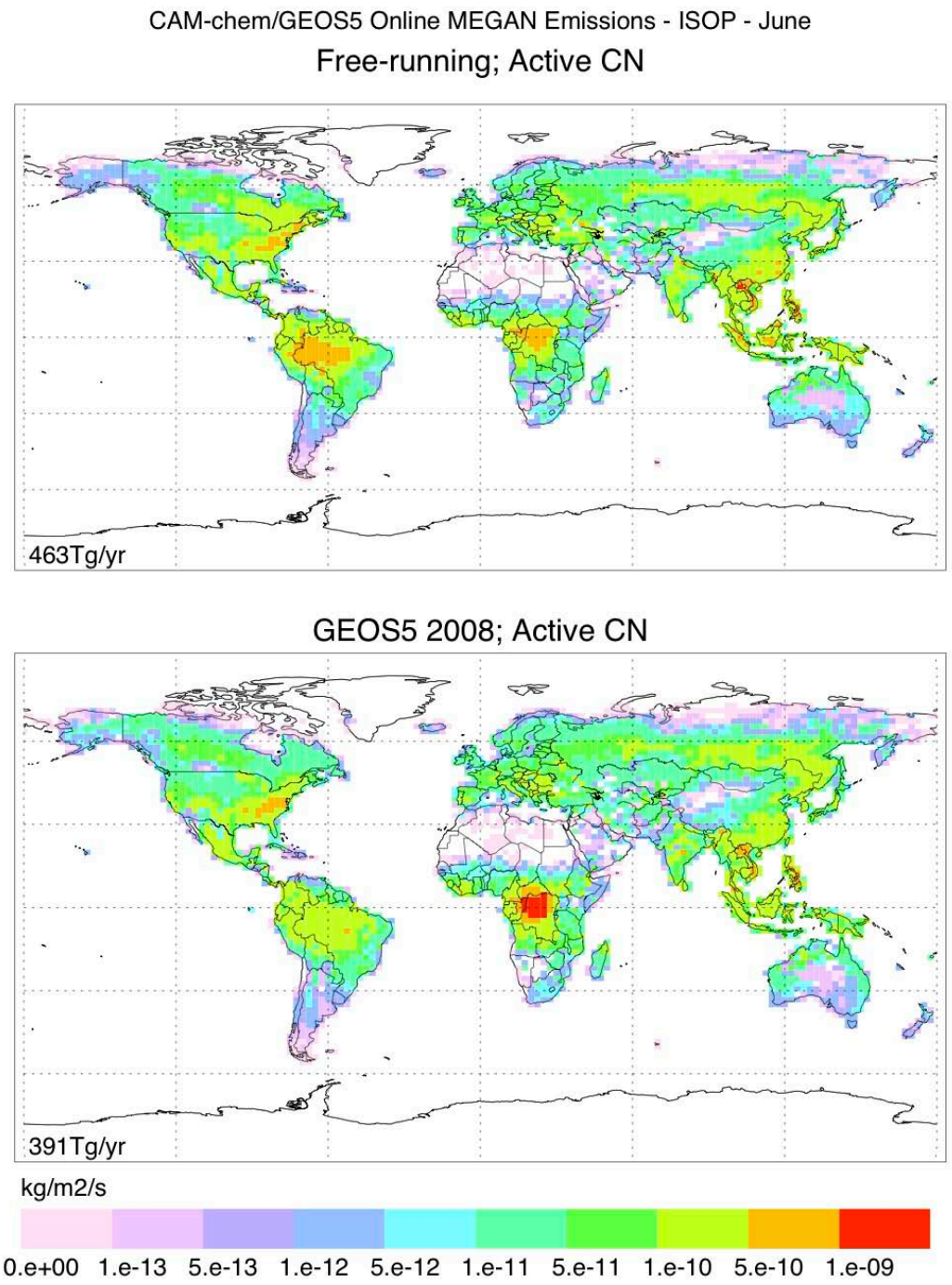
C10H16 = pinene_a + carene_3 + thujene_a

Isoprene emissions in CAM-chem

free-running

vs

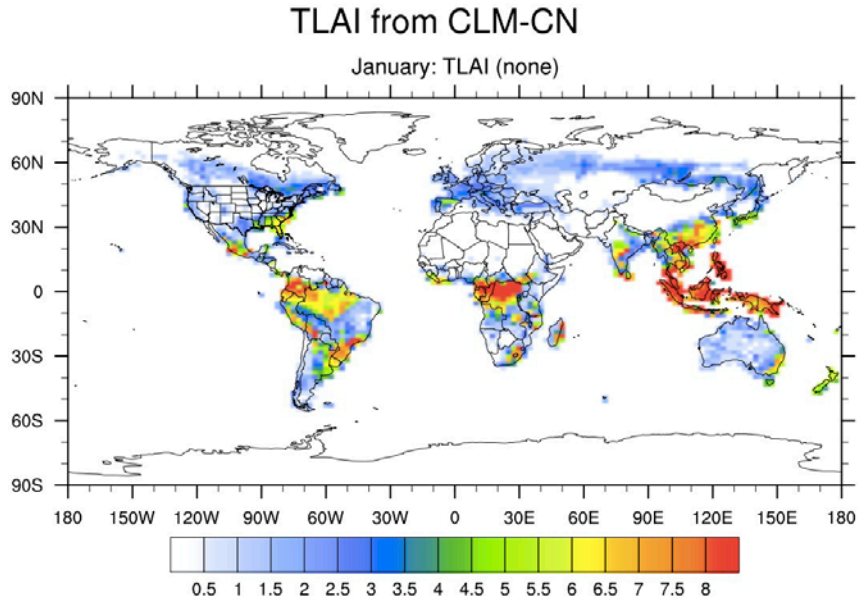
GEOS-5 met.

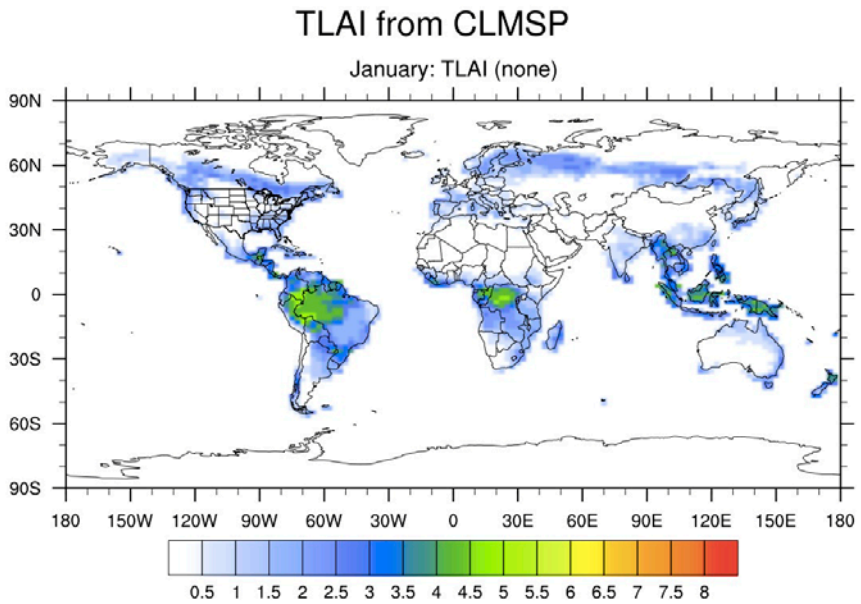


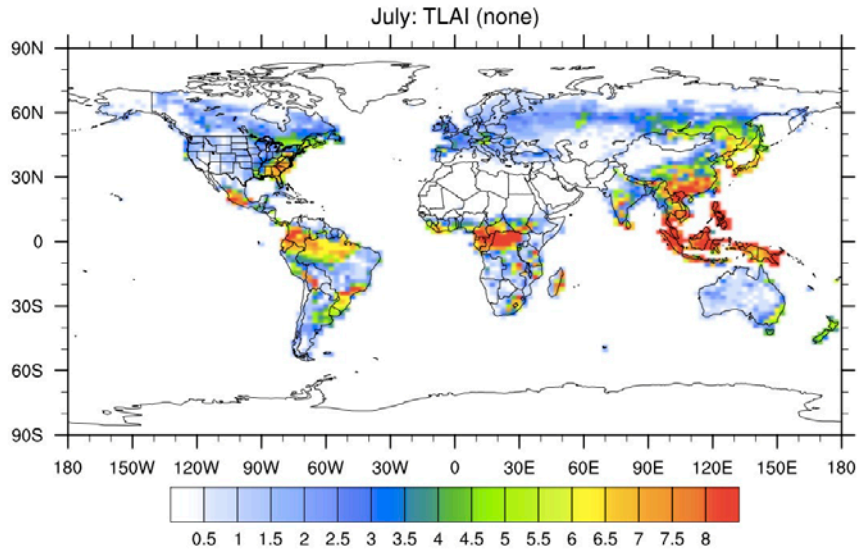
Differences in emissions result of different:

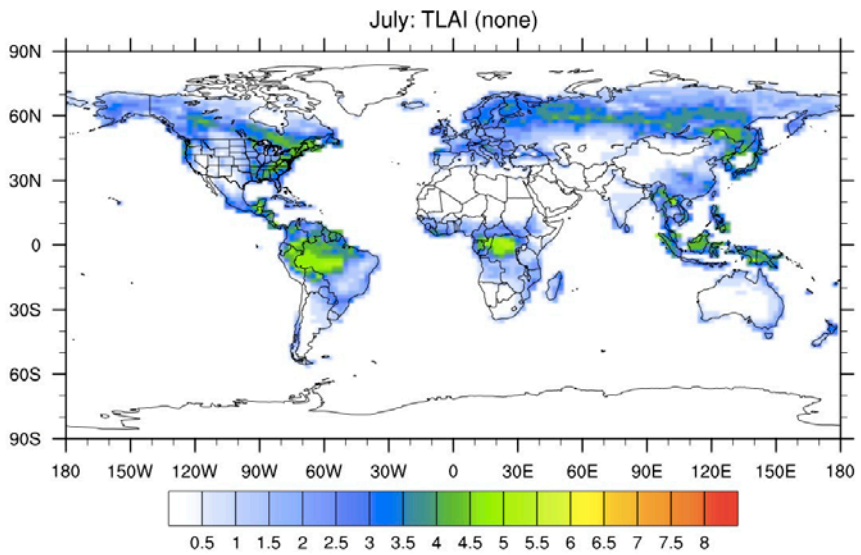
- Surface Temperature
- Radiation
- Shaded/Sunlit LAI

Simulated vs Specified LAI
(CLM-CN on vs CN off)





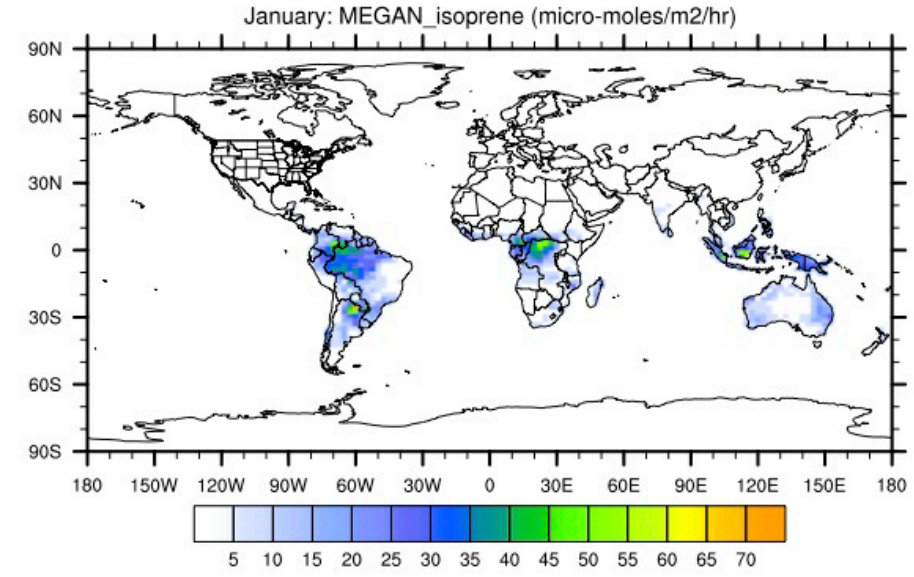


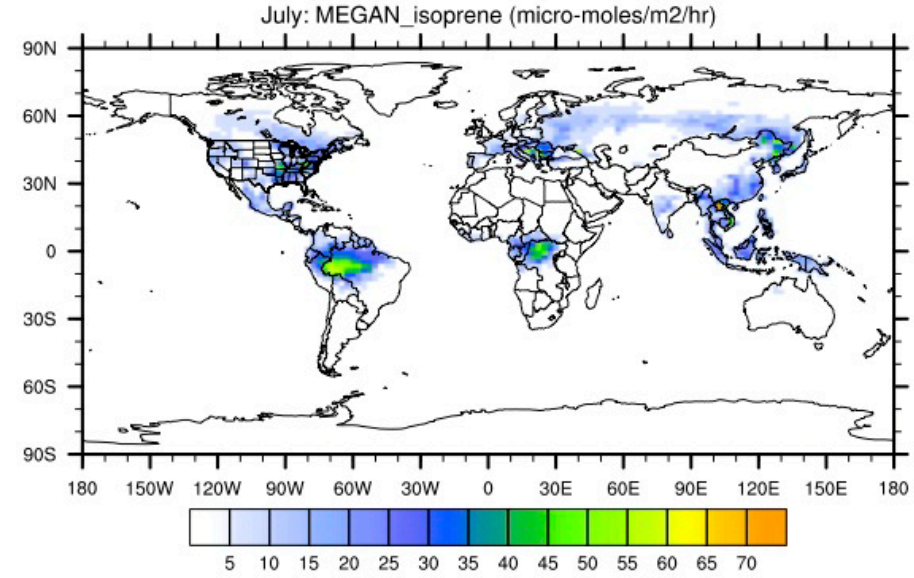


CLM WG is working on reducing the high LAI in CLM-CN

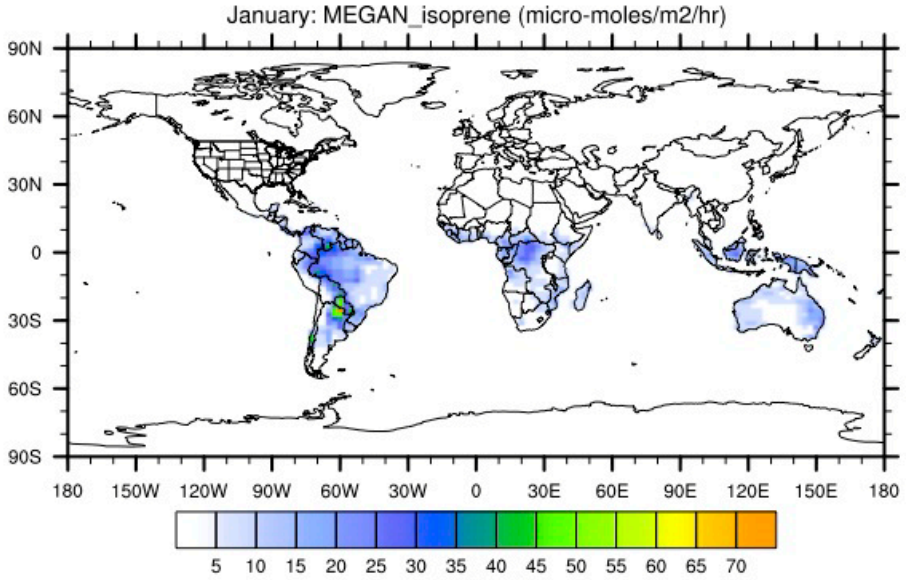
Isoprene emissions for Simulated vs Specified LAI (CLM-CN on vs CN off)

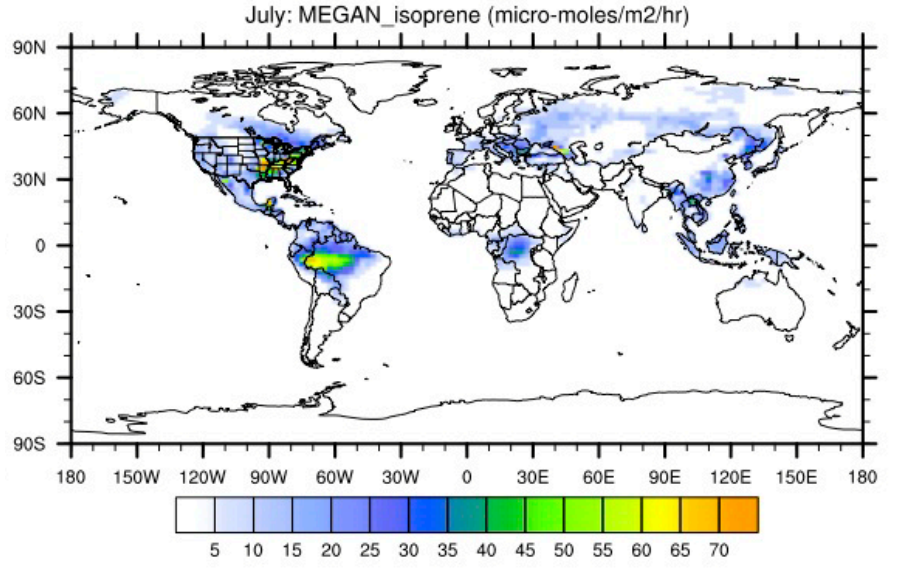
CN on (458 Tg/yr)



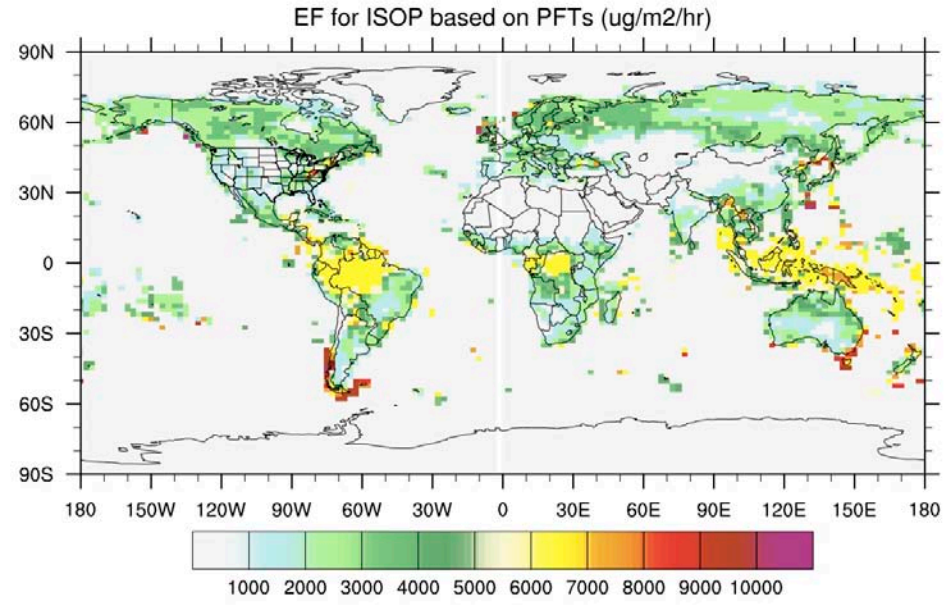


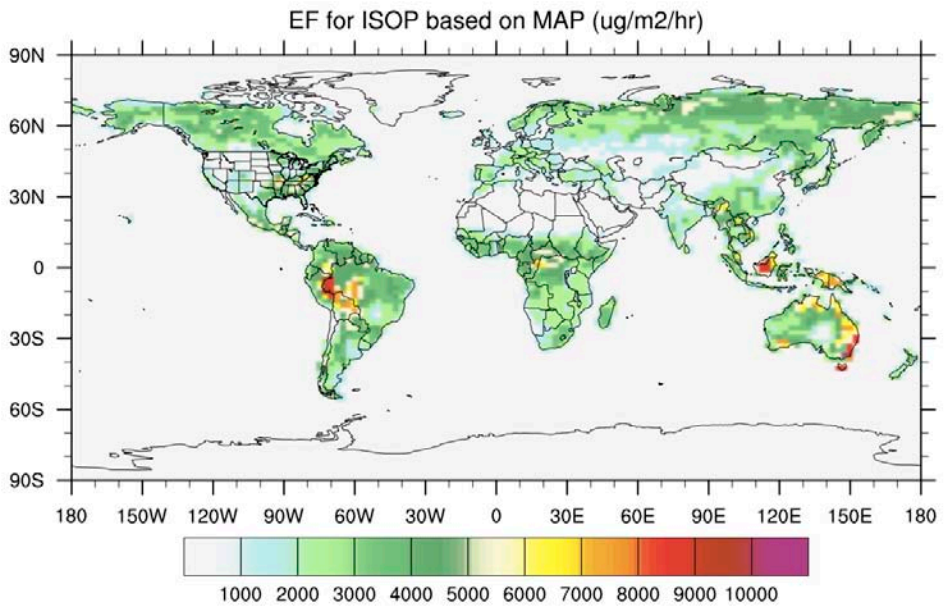
CN off (487 Tg/yr)





PFT-based vs Mapped Emission Factors

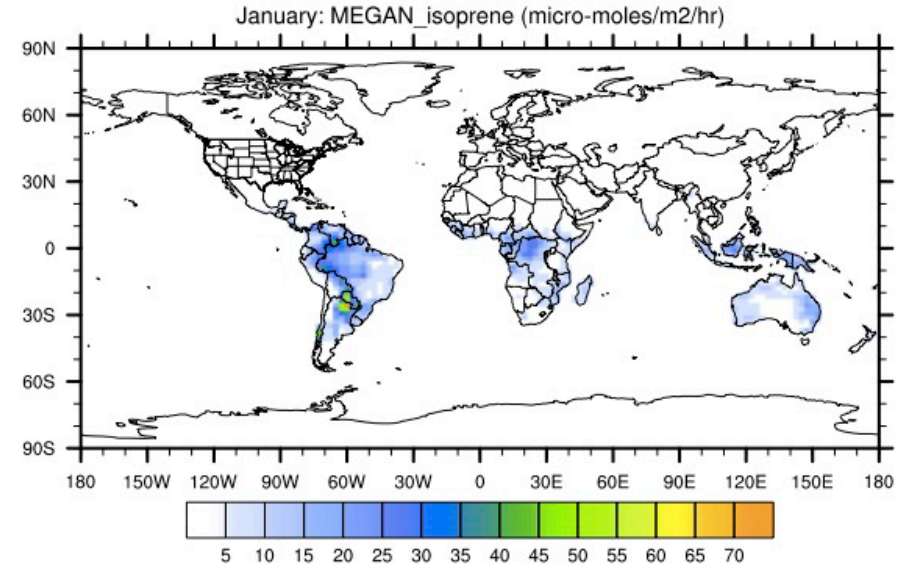


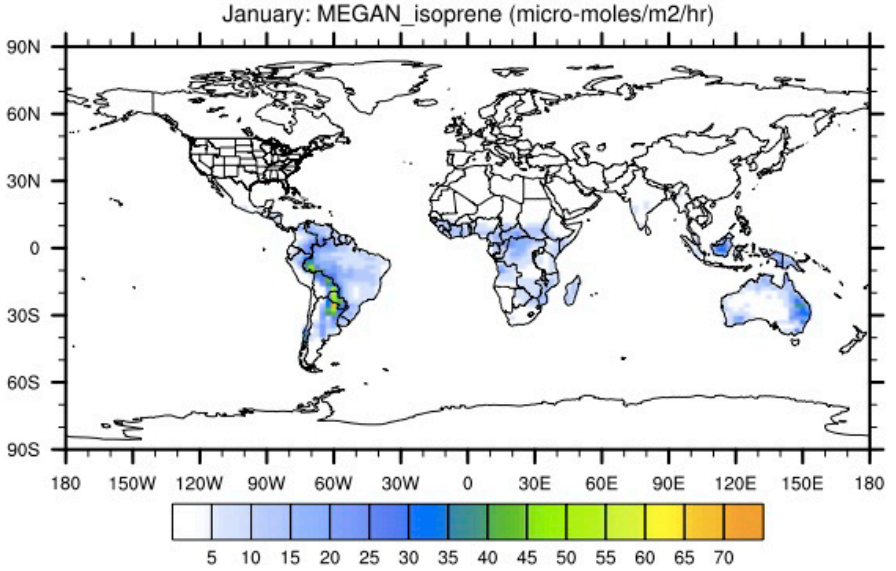


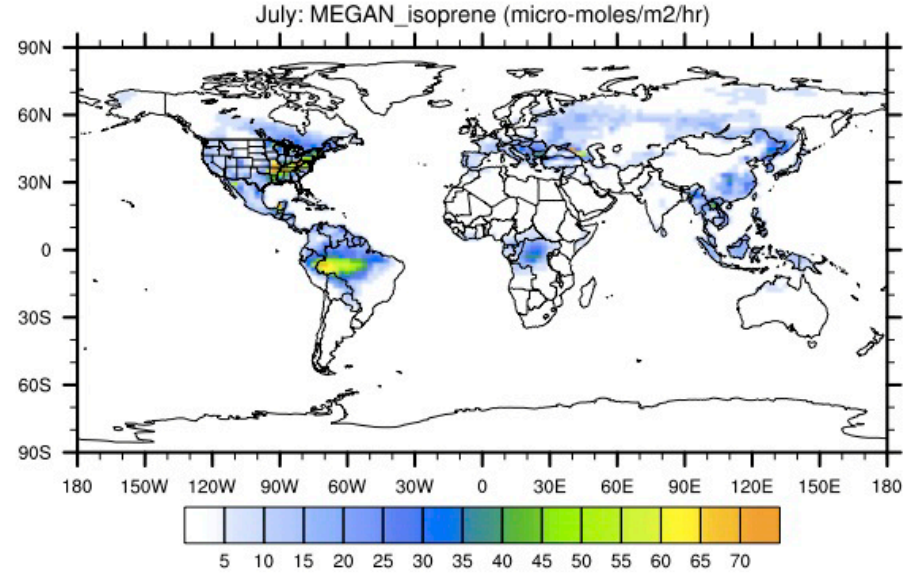
$EF[lon,lat] = \Sigma\ (\varepsilon_{PFT}\, f_{PFT}[lon,lat])$

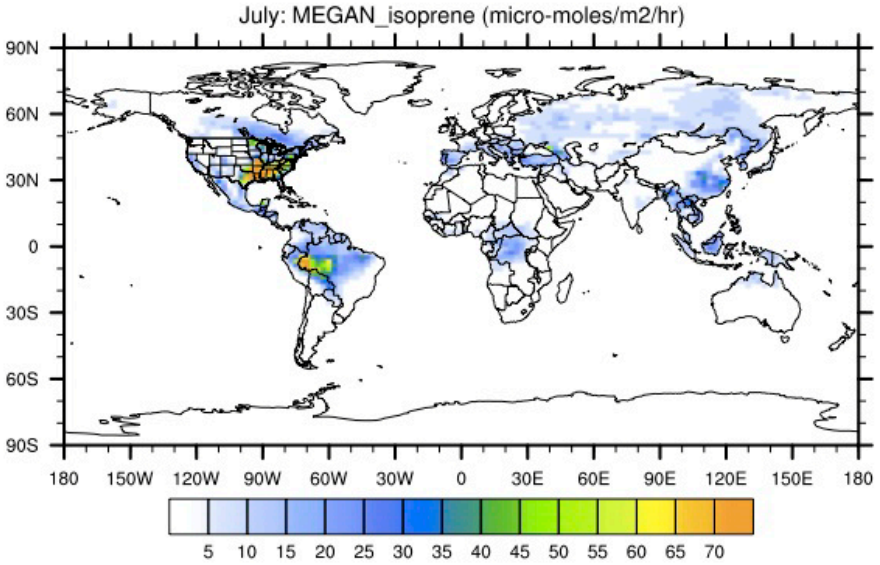
EF[lon,lat] read from file

Emissions from PFT-based vs Mapped Emission Factors









Total: 458 Tg/yr

Total: 430 Tg/yr

Available for use

- On bluefire in sandbox
- Will be in next release

- *Guenther et al.* description paper to be submitted soon